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THE CORN ROOT-WORMS.

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Among the many enemies of Indian corn two forms of slender, soft-bodied, whitish larvæ known as root-worms are prominent through their injuries. When the plants are found to be withering or when the ears fail to fully develop, forming "nubbins," without any visible cause, the earth about the roots should be searched. It then frequently happens that root-worms are found at work. They operate somewhat in the manner of wireworms, and the two forms vary somewhat in the nature of their operations, as well as in the territory which they ravage. They are the young of two species of leaf-beetles of the family Chrysomelidæ and of the tribe Galerucini.

The species which inhabits the middle western region is the western or northern corn root-worm (*Diabrotica longicornis* Say). Its injuries are practically confined to the middle West, where it would be a very serious pest were it not that progressive farmers in that region have adopted as a part of a sound agricultural routine a system of rotation which greatly reduces losses that might otherwise be sustained.¹ In spite, however, of the best methods of tillage, losses due to this insect are reckoned in millions of dollars annually. Thus Prof. F. M. Webster estimated the damage accomplished by this pest to corn in 24 counties of Indiana alone in 1885 at nearly \$2,000,000, this judgment being based on a loss of \$16,000 sustained by one farmer and a personal knowledge of the destructive abundance of the insect throughout that State.

The second species is the Southern corn root-worm (*Diabrotica 12-punctata* Ol). It occurs generally throughout nearly the whole of the United States, but fortunately its injurious range is somewhat closely restricted to the southern States, though in recent years it is showing a disposition to extend depredations into more northern regions.

The former species attacks first the fibrous roots and later the larger ones which it frequently destroys to such an extent that the infested plants may easily be pulled up by hand after they are seen to wither. The latter, at least in the maturing stage, eats directly into the stalk at a point near the upper whorl of roots. If injury by either species is not extensive, the ears, as previously stated, do not entirely develop.

¹For more detailed information see Forbes, 18th Rept. St. Ent. Ill., 1891-92 (1894, pp. 146-165); Bul. 44, Univ. Ill., May, 1896, pp. 282-296; Webster, Ind. Agl. Rept., 1885, author's ed., pp. 6-10; Riley, Insect Life, Vol. IV, pp. 104-108.

THE SOUTHERN CORN ROOT-WORM.

(Diabrotica 12-punctata Ol.)

This species is also known in the South as the "bud-worm" and less commonly as the "drill worm." In some regions it is recognized only by the former name, while the latter is of more recent use. The beetle is familiar to most persons in its occurrence on cucumber, squash, and other cucurbits. It frequents the flowers, and by peeping into them one or more beetles and the places where they have gnawed the petals may be seen, for they are among the most omnivorous of insects and appear to be able to subsist on any form of vegetation on which they may happen to alight. They are, in fact, to be found in practically all fields of corn and in gardens everywhere, but it is seldom that the larvæ

are associated with the beetles except by those well versed in entomology or who have had experience with both forms of insects. The species is best known northward as the twelve-spotted cucumber beetle.

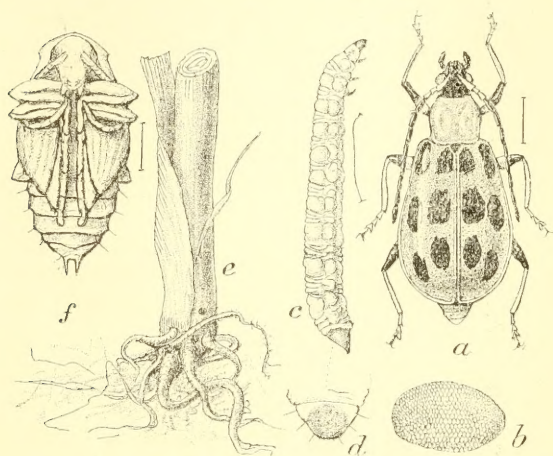


FIG. 1.—Southern corn root-worm (*Diabrotica 12-punctata*): *a*, beetle; *b*, egg; *c*, larva; *d*, anal segment of larva; *e*, work of larva at base of cornstalk; *f*, pupa—all much enlarged except *e*, which is reduced (reengraved after Riley, except *f*, after Chittenden).

DESCRIPTIVE.

This insect has four stages, adult or beetle, egg, larva, and pupa.

The beetle is elongate pyriform, yellowish green in color, and the elytra or wing-covers are marked with twelve black spots (fig. 1, *a*). The head is black, as are also the legs, except portions of the femora or thighs. The length is one-fourth of an inch or a little longer.

The egg (*b*) does not differ materially from that of related species, such as the striped cucumber beetle, except in size. It is broadly oval in shape, measuring in the average 0.025 inch in length. The color is dull yellow, and the surface is closely and somewhat regularly faceted.

The larva (*c*) is slender, even thread-like, delicate and soft-bodied, and white or yellowish in color. The body is smooth and cylindrical, the head short and rounded, and brownish in color, and the first thoracic segment is also slightly brown, while the anterior extremity as a rule ends in two points.¹

¹ Less acute than in the striped cucumber beetle (*Diabrotica vittata*) and sometimes obtuse or wanting.

The above characters, with the aid of the illustrations (fig. 1, *c*, *d*), serve to distinguish this corn root-worm from young wireworms¹ with which they are often associated in injury to corn and other cereals, grasses, and other plants. Before changing to pupa this root-worm attains a length of about half an inch.

The pupa (fig. 1, *f*) presents no special features worthy of remark that are not shown in the accompanying illustration. It is white like the larva, and similar to that of the striped cucumber beetle.

GEOGRAPHICAL DISTRIBUTION.

The twelve-spotted cucumber beetle occurs commonly throughout that portion of the United States lying between the Atlantic seacoast and the base of the Rocky Mountains, and from New England to Florida. It also inhabits Canada in the North and extends in a southwesterly direction through Texas into Mexico. Throughout practically all this region, which includes portions of twenty-nine States, it is really abundant, though not nearly so destructive in the northern as in the southern States, where year by year more or less injury is accomplished by the larvæ or root-worms as far northward as Maryland, Virginia, and southern Ohio.²

FOOD HABITS.

The adult, as stated, is practically omnivorous. Its known food materials are legion and include, besides the blades, green ears, silk, and pollen of corn, the partly matured kernels of wheat, corn, and oats, the foliage of alfalfa, corn, clover, crimson clover, cotton, rye, tobacco, beets, cabbage, kale, cauliflower, turnip, mustard, cucumber, cantaloupe, watermelon, pumpkin, squash, okra, potato, tomato, rhubarb, and asparagus, the leaves and pods of beans, as also the buds, flowers, and sometimes the leaves of fruit trees, including apple, pear, quince, apricot, cherry, and peach, the buds and flowers of roses, dahlia, sunflower, aster, canna, chrysanthemum, grapevine, sweet pea, cosmos, cultivated *Bidens*, and raspberry, the fruit of apple, melons and other cucurbits. To all of these more or less serious injury is inflicted. Among wild plants, or such as are of little practical utility, frequented by the beetles for food are golden-rod (*Solidago*), wild sunflower, New Jersey tea (*Ceanothus*), pokeweed (*Phytolacca*), milkweed (*Asclepias*), groundsel (*Senecio*), horse nettle, *Nelumbo*, *Impatiens*, and *Amorpha*.³

¹ The latter, it should be stated, are usually more or less flattened, especially at the head, while the posterior extremity is usually toothed, notched, or pointed. They also serve to separate this root-worm from maggots of several small flies, such as the seed-corn maggots, which also infest corn roots. The root-feeding maggots, however, are footless, while the root-worms have six legs placed near the head.

² In the Pacific States it is replaced by a similar very closely related species, *Diabrotica soror* Lec., which is sometimes quite injurious.

³ Some of the food plants above enumerated have not hitherto been recorded.

Larvæ or pupæ have been observed at the roots of corn, wheat, rye, millet (*Panicum miliaceum* and *Bromus unioloides*), beans, Rudbeckia, and sedges of the genera *Cyperus* and *Scirpus*. The favorite larval food plants are evidently Gramineæ, including various cereals and grasses, and the Cyperaceæ or sedges.¹

The presence of this root-worm in a field of corn gives origin to the loss of the roots, injury varying according to the age of the corn and the severity of attack, and somewhat also upon the condition of the weather and of the soil infested. Injury is manifested in various ways, from the death of a plant to slight retardation in its growth or what is sometimes termed "spindling," or a yellowish and unhealthy look. In plants 6 inches or less in height the perforations of the stalk (fig. 1, c) are characteristic, and usually show just below the surface of the ground. This is accompanied by withering of the plant, which is frequently killed outright. It is this appearance which has given the insect the name of "bud-worm." Quite frequently plants are destroyed almost as soon as sprouted. As plants grow, the signs of injury vary according to the degree of development. If plants suspected of harboring this species are pulled up and shaken over a sheet of cloth or paper, the root-worms can be dislodged, and it is not difficult to distinguish them from any other forms of insects to be found in the same locations, with the exception of the western corn root-worm, which, however, seldom occurs in the same regions.

LIFE HISTORY.

This beetle is one of the earliest as well as latest species. About the District of Columbia the beetles have been seen abroad by the last week in March, and eggs have been obtained from April 18 to May 9. Beetles have been seen freely feeding until the middle of November, when the flowers which had furnished them with food began to wilt and die. Just when the first new generation appears seems not to have been recorded, but several beetles, still immature, have been seen in the open by the writer on June 12, others were reared the same day and in July, and still others were seen, newly transformed, late in September. Although the writer can not speak with positiveness as yet as to the number of generations, these indications show the probable production of two and perhaps three generations annually in the District of Columbia, and there is the possibility of four in the insect's more southern range.

Eggs are laid, as has been stated, at the base of the insect's food plant, and have been observed by the writer to hatch in six and seven days in cool May weather. One individual deposited 202 eggs.

¹ Larvæ have been found and reared by the writer from about the roots of Jamestown weed (*Datura*) and pigweed (*Amaranthus*), and it is not improbable that they feed on these plants.

NATURAL ENEMIES.

The beetle is parasitized by a Tachina fly, *Celatoria diabroticæ* Shimer (fig 2), which develops in the abdomen of its host. It is preyed upon by the wheel bug, *Arilus (Prionidus) cristatus* Linn., and many birds feed to a considerable extent on the beetles. It is also subject to a bacterial disease.¹

REMEDIES.

For the root-worm the use of insecticides on growing corn is impracticable. In fact, we can not reach the root-worm stage to any extent with poisons. Therefore we must have recourse to farming methods. Injury in corn fields is most abundant when the seed has been planted in bottom lands, and if planting is necessary in such locations, it should be done late, in Georgia by the first of May, according to Quaintance; or attack may be so distributed that damage will be inconsequential by dropping eight or ten grains of seed corn in each hill. Of still more importance, however, is judicious crop rotation. Numbers of crops are not injured to any extent by the Southern corn root-worm, and of these are cotton, buckwheat, the smaller grains, and various garden vegetables other than beans and cucurbits. Experience will teach which of these can best be employed as alternates. It is inadvisable to plant squash and pumpkin to any extent in rows between the hills of corn, more particularly in regions where injury by this species has been previously observed.



FIG. 2.—*Celatoria diabroticæ*, fly parasite of corn root-worm beetle—much enlarged (original).

For the beetle as it occurs on cucumber, squash, and other cucurbits the same remedies in use against the striped cucumber beetle should be pursued.² In its occurrence on most other crops it can be controlled in the same manner as other leaf-beetles, for example, the Colorado potato beetle, by applying an arsenical alone or combined with Bordeaux mixture, the latter having a repellent effect. Arsenate of lead is preferable to Paris green as it adheres to the foliage better and is not washed off so readily by rains, and there is little or no danger of scorching.

There is little that can be done to lessen the number of beetles for ensuing years, because of their roving habits and their ability to subsist on such a vast variety of vegetation. The species appears to have no particular food material, if we except flowers of cucurbits, goldenrod, and some others, and thus the beetles are seldom found congregated where they could be destroyed "at wholesale."

¹ Forbes, 17th Rept. St. Ent. Ill., 1889 and 1890 (1891), pp. 71-73.

² See Circular 31, entitled "The Striped Cucumber Beetle (*Diabrotica vittata* Fab.)."

THE WESTERN CORN ROOT-WORM.

(Diabrotica longicornis Say.)

DESCRIPTIVE.

The beetle may be readily distinguished from its Southern congener by its nearly uniform pale, but usually distinctly grass-green, or greenish yellow color. (Preserved specimens usually lose this coloration to a considerable extent.) It is also smaller, of about the same size as the striped cucumber beetle, measuring about a fifth, or a little more, of an inch in length, and is a little more slender and less pear-shaped (fig. 3, *a*). In the earlier stage the Western corn root-worm very closely resembles the Southern species, all stages naturally being smaller, as would be expected in an insect of smaller size.

The egg. This applies particularly to the egg, which is of similar form and sculpture. It has only about 20 hexagonal pits in its longest

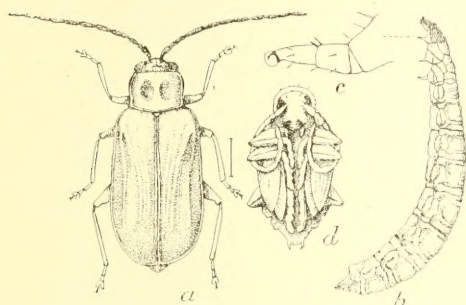


FIG. 3.—Western corn root-worm (*Diabrotica longicornis*): *a*, beetle; *b*, larva or root-worm; *c*, enlarged leg of same—all enlarged, *c*, more enlarged (original.)

diameter, compared with 30 to 35 in that of its congener. It is, moreover, dirty white instead of yellowish, and measures only .015 to .025 inch as against .02 to .03 in the Southern species.

The larva, when fully mature, attains a length of only four-tenths of an inch as compared with half an inch in the case of the Southern form.

In other respects they are very similar, as will be noted by comparison of the illustration of the Western species (fig. 3, *b*) with the Southern (fig. 1, *c*). The anal segment in the larva under consideration is always blunt, never armed with tuberculous points.

The pupa (fig. 3, *d*), judging from available material, though smaller, is proportionately wider, giving it a more robust appearance than in the Southern species.

DISTRIBUTION.

This species, which was first recognized as a pest in 1874, has a more limited geographical range than the preceding, and is moreover confined in its field of destructiveness. We know of its occurrence from central New York and Canada, including Nova Scotia, westward to Kansas and Nebraska. Injurious occurrences are limited to the States of Illinois, where it is most troublesome, Indiana, Iowa, Kansas, Nebraska, Ohio, and Missouri. It does not occur in destructive numbers in Kentucky; in fact it is rarely found in that State. It was very injurious in the vicinity of Chillicothe, Ohio, in 1903, and injuries were reported at Circleville,

just south of Columbus, Ohio, the same year. Reports from southern Ohio in 1904 indicate that the species is increasing in abundance in that region.

FOOD AND OTHER HABITS.

It has already been stated that corn is the only known host plant of the larva. The beetles show a disposition to feed on a variety of plants, but are more choice than the southern species. In the experience of the writer and evidently of others also, the beetles, which are naturally pollen feeders, like other members of this genus, are partial to the blossoms of thistle (in which they deeply imbed themselves), sunflower, and goldenrod, and are less frequently found on cucurbits. It is probable that the beetles do some damage to corn by eating the pollen and gnawing the silk and tassels, thus preventing cross-fertilization and causing a partial blasting of ears. Other plants, also, are frequented for the sake of pollen, and the list includes ragweed and smartweed growing between hills of corn, clover, and some other plants. In late fall the beetles have the same habit as the twelve-spotted and striped cucumber beetles, of gnawing into ripe squash and pumpkin in the field, and they do some injury in this way. The plants attacked include bean, sorghum, and cotton, which are visited for pollen, and ripe apples, which are sometimes injured in the same manner as cucurbits; and the beetles have been noticed gnawing the ears of corn, more particularly where they have first been injured by birds or grasshoppers. Since the beetles have been observed by Forbes to feed on fungi, blights, rusts, etc., there is no doubt that they do some harm, which has been positively ascertained to be the case with the striped cucumber beetle, in acting as conveyors of fungous diseases from unhealthy to vigorous plants.

The species is credited with being single-brooded. The beetles occur normally in the field, like the Southern species, until November, subsisting upon such flowers and other vegetation as can be obtained at that time, and in open winters have been noted abroad as late as the middle of December, which is, in the writer's opinion, proof positive that the beetles hibernate, but the observations of Messrs. Forbes and Webster indicate that as a rule the species passes the winter in the egg condition, in the earth. If this hypothesis is true it differs from the great majority of leaf-beetles. Eggs, so far as known, are deposited in fields of corn late in the season and hatch the following spring. Larvæ have been seen in central Illinois the second week in June, and the beetles have been reported in southeastern Iowa toward the end of June. Forbes assigns the first weeks of August and October as the average times for the first and last deposit of the eggs, and recognizes a period of eight or nine weeks for the passage of a generation from the first to the last stage. The egg-hatching period is set from the middle of May to the middle of July and a little later.



Eggs are deposited in the earth in more or less scattered clusters of three to ten, and at a depth varying from 1 to 6 inches, all being placed about the roots in a space a few inches around each hill.

The developing larvæ live entirely beneath the surface, feeding on the roots, which they mine either upward or downward, and seem capable of traveling from one root to another. Pupation also takes place underground, and pupæ may be found in considerable numbers, at the proper period, about infested corn roots. When the beetles begin to issue, toward the latter part of August, they are first noticeably abundant on thistle blossoms, and afterward on other plants blooming at this season. Like the twelve-spotted cucumber beetle, they show a disposition, late in the season, to disperse before seeking quarters for hibernation or the deposit of their eggs, flying from one field to another.

PREVENTION AND REMEDY.

This species is more readily controlled than the Southern corn root-worm; in fact, losses can be prevented by simply following crop rotation. Since the insect, as far as observed, feeds in its larval condition only on corn, the planting of infested land to any other crop leads to the starvation of the young when they hatch in the spring. This is no mere inference, but has been tested time and again. In Illinois, according to Forbes, it is ordinarily safe to plant corn two years in succession, but it is unwise to plant it again without an alternate. It is also imprudent to plant corn in fields or meadows in which the beetle has been observed in great abundance on clover and certain weeds in late October the previous year.

One other measure is to be recommended, as a general farm practice. It consists in the maintenance of the fertility of the soil by the use of manures and other fertilizers. Although this does not diminish attack, it sometimes enables the plants to withstand injury.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *March 23, 1905.*

